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MODIFIED WOOD AND MANUFACTURE THEREOF  
[改質木材とその製造方法]

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[SCOPE OF CLAIMS]

[Claim 1] A modified wood, wherein at least one type of metallic compound selected from the group consisting of a metal oxide, a metal hydroxide, and a metal oxyhydroxide is fixed only to the surface of a wood.

[Claim 2] The modified wood according to claim 1, wherein the aforementioned metallic compound is a metallic compound containing at least one type of metal selected from the group consisting of silicon, iron, copper, zinc, silver, tin, mercury, lead, arsenic, titanium, vanadium, chromium, manganese, cobalt, nickel, aluminum, molybdenum, antimony, bismuth, barium, and cadmium.

[Claim 3] A method of manufacturing a modified wood, wherein a colloidal solution containing a metallic compound formed from at least one type selected from a metal oxide, a metal hydroxide, and a metal oxyhydroxide is brought into contact with a wood, and the metallic compound is fixed only to the surface of the wood.

[Claim 4] The method of manufacturing a modified wood according to claim 3, wherein contact between the metallic compound and wood takes place at between 50° C and 80° C.

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<sup>1</sup> Numbers in the margin indicate pagination in the foreign text

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNOLOGICAL FIELD OF THE INVENTION]

This invention relates to a modified wood and a method of manufacturing the same, said modified wood having fixed to it a metal oxide, a metal hydroxide, or a metal oxyhydroxide.

[0002]

[PRIOR ART] Apart from natural wood, there are various types of wood material such as veneer lumber and glued-laminated wood. Because it can be easily logged and has excellent processability in processes such as cutting, polishing, and nailing, natural wood has been widely used as a raw material. Moreover, with the object of preserving timber resources and improving material quality, there has been substantial production in recent years of veneer lumber, glued-laminate timber, and the like using materials such as wood flour, wood chips, laminates, and sawdust. These wood materials have been widely used as construction materials for the pillars, floors, roof spaces, and interiors of wooden buildings, as well as for furniture, interior members, and so forth. Furthermore, wood-cement boards, such as wood wool cement board and wood chip cement board, formed by compression molding of wood wool or wood chips and cement and board formed by heat-pressure molding of wood fragments as the main raw material with a thermoplastic resin as adhesive (e.g. particle

board), have been used as materials with excellent non-combustibility.

[0003] However, the woody raw material itself, in addition to being readily combustible, also suffers from disadvantages such as insect damage by white ants, marine borers, and the like, rotting and decay caused by moisture, and warping and dimensional distortion through contraction due to repeated absorption of moisture and drying. Moreover, in wood-cement board, curing of cement is hindered by wood extractives, thus lowering the strength of the wood-cement board. Various processing methods have been proposed to overcome the aforementioned problems without compromising the advantages inherent in wood. One wood modification method often used to improve flame retardance, rot-proofing, insect proofing, and dimensional stability is the decompression/compression method of degassing wood under low pressure and then injecting chemical agents for flame retardance, rot proofing, or insect proofing. In this method, although chemical agents can be injected quickly and efficiently, injection of chemical agents also has a detrimental effect on the woody tissue. One remedy for this problem is a diffusion method whereby the chemical agent is diffused inside the wood and mobilized internally. Based on this approach, there have been several proposals employing a double diffusion method whereby an inorganic ion is used as the

diffusion agent, and after injection, the inorganic ions are converted into an insoluble inorganic substance.

[0004] For example, Japanese Unexamined Patent Application Publication No. H07-40311 describes a wood containing an iron compound, wherein the wood was immersed in an aqueous alkali solution and an aqueous ferrous ion solution in that order, and the iron compound was reliably incorporated into the wood. In this example, the amount of iron compound fixed to the wood was large at 0.1 wt. %, and the immersion time was long at 1 hour.

Japanese Domestic Re-Publication of PCT International Application No. H05-801143 proposes a reinforced fiber for civil engineering and construction wherein a metal oxide is fixed to a mainly polyolefin-based fibrous substance (containing fibers of wood or the like.) It is shown that with this method, metal oxides can easily be fixed to a fibrous substance, dispersability in water or cement slurry and affinity between cement and fibers can be enhanced, cracking due to drying can be effectively prevented, and an effective asbestos substitute can be obtained.

[0005] Moreover, Japanese Unexamined Patent Application Publication No. S62-116105 discloses a method of manufacturing a modified wood whereby wood is impregnated with a treatment liquid containing metal ions and a treatment liquid containing substantially neutral phosphate ions, and a metal salt of

phosphoric acid that is sparingly soluble in water is thus produced in the wood. However, in this method, the metal ion is restricted to those that form a metal salt of phosphoric acid that is sparingly soluble in water, such as aluminum, calcium, and magnesium, and in addition, a long treatment time of several hours' immersion is required. Furthermore, in the above method, in order to produce a compound sparingly soluble in water, immersion in the metal ion-containing liquid must be followed by immersion in an ion-containing solution that will create an insoluble compound. The treatment is thus complicated and also takes a long time.

[0006] As a method intended to overcome these failings, Japanese Unexamined Patent Application Publication No. S62-288149 discloses a method of manufacturing a wood-cement board by blending into [cement] mixing water a metallic compound, which forms a highly stable complex by reacting with the wood extractives that hinder cement curing. However, said invention's blending of a metallic compound into cement mixing water was in fact unable to solve the problem of the loss of strength in a board material caused by hindering of cement curing.

[0007]

[PROBLEM TO BE SOLVED BY THE INVENTION] In view of the foregoing, it is an object of this invention to provide a modified wood, and method of manufacturing the same, said modified wood being

characterized in that, by fixing a colloidal metallic compound to wood, an insoluble compound is fixed to the wood surface in a short period while the woody tissue remains protected, and functions such as flame retardance, insect proofing, rot proofing, and dimensional stability are conferred.

/3

[0008]

[MEANS FOR SOLVING THE PROBLEM] The object of this invention was achieved by developing [1] a modified wood, wherein at least one type of metallic compound selected from the group consisting of a metal oxide, a metal hydroxide, and a metal oxyhydroxide (hereafter referred to collectively as 'metallic compounds'), is fixed only to the surface of a wood; [2] The modified wood according to [1], wherein the aforementioned metallic compound is a metallic compound containing at least one type of metal selected from the group consisting of silicon, iron, copper, zinc, silver, tin, mercury, lead, arsenic, titanium, vanadium, chromium, manganese, cobalt, nickel, aluminum, molybdenum, antimony, bismuth, barium, and cadmium;

[0009] [3] A method of manufacturing a modified wood, wherein a colloidal solution containing a metallic compound formed from at least one type selected from a metal oxide, a metal hydroxide, and a metal oxyhydroxide is brought into contact with a wood, and the metallic compound is made to fix only to the surface of

the wood; and [4] The method of manufacturing a modified wood according to [3], wherein contact between the metallic compound and wood takes place at between 50° C and 80° C.

[0010]

[EMBODIMENTS OF THE INVENTION] When a metal salt is dissolved in a solvent and hydrolysis is performed under controlled conditions of heating, pH, and so forth to form a metallic compound deposited in colloid form, the particle size thereof can easily be made smaller than 0.14 µm, which is the diameter of the finest spaces in the pathways in the wood through which said metallic compound is intended to pass. When such a colloid solution is used, although it was thought that the colloidal metallic compound would be able to soak into the wood, surprisingly, the colloidal metallic compound only fixes to the surface of the wood (herein, 'surface' includes the thin inner surface) with virtually no penetration into the inner wood. Despite this, functions such as enhanced flame retardance, insect proofing, rot proofing, and dimensional stability were conferred to the wood. As a result of this discovery, this invention was completed.

[0011] This invention is described in detail below. The mechanisms by which flame retardance, insect proofing, rot proofing, and dimensional stability are conferred are now described. Flame retardance can be attributed to several

different mechanisms. Even flammable substances such as wood can be made flame retardant if formed into a complex by suitably mixing with a nonflammable hydraulic substance such as a metal oxide. For example, wood chip cement board is recognized by JIS as a quasi-noncombustible material.

[0012] In other words, by covering wood with a metallic compound, carbonization of wood is promoted, and the resultant carbonized layer acts as a thermal barrier, providing a flame retarding effect in the wood. Flame retardance is also thought to result from heat absorption due to decomposition of metallic compound and release of non-evaporable water. In cases where halogens are included, it is thought that chain reactions in combustion are inhibited and non-flammable gas is generated. Metallic compounds that have this effect include oxides, hydroxides and oxyhydroxides of silicon, iron, titanium, vanadium, manganese, cobalt, nickel, aluminum, and molybdenum.

[0013] Insect proofing and rot proofing are achieved when metallic compounds of silver, copper, zinc, tin, mercury, lead, arsenic, antimony, bismuth, barium, cadmium, and chromium, known as inorganic antimicrobial agents, are fixed to the wood. In all cases, as well as giving flame retardance, insect proofing, and rot proofing, the metallic compound covers the wood surface and so fixes to and closes off gaps in the wood, making moisture absorption difficult and promising a good degree of dimensional

stability. Moreover, by fixing a metal oxide of a conductive metal such as iron, it is possible to confer conductivity.

[0014] Until now, water soluble wood extractives such as cellulose, lignin, tannin, humic acid, and sugar have been regarded as a hindrance to cement curing. However, though the details are unclear, when wood is treated with the metallic compound colloid of this invention, these wood extractives are stabilized by, for example, formation of chelates, or by complex salts or double salts, and therefore, when such wood is used in wood-cement board, there are no adverse effects on cement curing. By fixing a metallic compound to wood, this treatment is also able to inhibit peeling of the coating surface by producing fine indentations in the wood surface.

[0015] Below, a method of manufacture according to this invention whereby a metallic compound is fixed to wood is described. The modified wood of this invention is manufactured by combining the processes of producing a colloidal solution of a metallic compound by mixing at least one type of metal salt and a solvent, immersing wood in the colloid solution obtained in the previous process, imparting energy to the colloid solution and / or adjusting pH, and cleaning in water the wood treated by adhesion of the metallic compound. In production of the colloid solution, a colloid solution of a metallic compound can be prepared by dissolving a metal salt in a solvent and

performing hydrolysis by controlling reaction conditions such as heat and pH. When this colloid solution is coated onto the wood surface or wood is immersed in the colloid solution, the colloidal metallic compound fixes to the wood surface in a short period.

[0016] The metallic compound for adhesion is a metallic compound containing at least one type of a metal oxide, metal oxyhydroxide, metal hydroxide or the like, as in  $\text{Fe}_2\text{O}_3$ ,  $\text{FeOOH}$ , and  $\text{Fe}(\text{OH})_3$ . Moreover, metallic compounds of two or more types of metal may be used for adhesion. Although there are no particular restrictions on particle size, the particles are between 1 nm and 1000 nm depending on the type of metal, and in the solution, the particles are in a colloidal state, static and floating without sedimentation. The hydrolysis conditions for producing the colloidal metallic compound differ according to factors such as type of metal salt, concentration, temperature, stirring, etc.

[0017] In producing the metal colloid solution of this invention, a metal salt is fully dissolved in a solvent, then hydrolysis is carried out by imparting energy such as heat and adjusting pH, thereby producing a colloidal solution of a metallic compound such as a metal oxide, metal oxyhydroxide, or metal hydroxide. In this case, for the metal salt, it is preferable to use at least one metal selected from the group consisting of silicon,

titanium, vanadium, manganese, iron, cobalt, nickel, aluminum, silver, copper, zinc, tin, mercury, lead, arsenic, antimony,

/4

bismuth, barium, cadmium, and chromium. Moreover, metal ions may be of any valence. Although the concentration of metal salt can be freely chosen, since a lower concentration gives a smaller particle size of the resultant colloidal metallic compound, a concentration of 1000 mmol/l or less is generally suitable. Even more preferable is a concentration of 100 mmol/l or lower.

[0018] For the counter-ion of the metal salt, those that are relatively cheap are used, such as chloride ions, sulfate ions, or nitrate ions, but also suitable are bromine or other halogen ions, sulfite ions, nitrite ions, phosphate anions, phosphoric acid ions, and hypophosphoric acid ions. Moreover, it is acceptable to use an organometallic compound having an ethoxy group, methoxy group, butoxy group, an oxalic acid ion, tartrate ion, or citrate ion, though not counter-ions, or to use a metal salt containing some of these. For the metal salt, one containing a metal hydroxide or oxide or part thereof may also be used. These should be used in a fully dissolved state for the production of the colloidal metal compound. Addition of a suitable acid and heat may be used when dissolving.

[0019] Although water is the most practical solvent for dissolving the metal salt, methyl alcohol, ethyl alcohol, other

organic solvents, or a water-containing organic solvent may be used. In cases where the metal salt itself does not easily dissolve in the solvent, dissolving may be carried out with the suitable addition of an acid or base and further heating. The acid may be a mineral acid such as hydrochloric acid or sulfuric acid, or an organic acid such as acetic acid or formic acid. As the base for dissolution or hydrolysis, easily obtainable alkalis or organic bases are used, such as sodium hydroxide, potassium hydroxide, or ammonia. The manufacturing temperature of the colloidal metallic compound can be freely chosen. A higher temperature is needed for faster internal movement by dispersion. A suitable temperature for this is 30°C or greater, and more preferably 50°C or greater.

[0020] The acid used for adjusting pH in producing the colloidal metallic compound may be a mineral acid such as hydrochloric acid, sulfuric acid, or nitric acid, or an organic acid such as acetic acid or formic acid. For the base, an easily industrially obtainable alkali is practical, such as sodium hydroxide, potassium hydroxide, or ammonia, but other inorganic or organic bases may also be used. For pH adjustment in the production of the colloidal metal oxide, it is preferable to slowly add the acid or base for colloid precipitation while stirring, keeping the acid and base concentrations as low as possible. Components having a buffer action may also be added to control the pH of

the solution in which the colloidal metallic composition is present. In addition, by adding components that form complex ions, flocculation and sedimentation of metal oxides can be prevented or lessened.

[0021] The composition and particle size of the metal colloid solution can be controlled by changing factors such as the type of metal in the metal salt, metal salt concentration, temperature, pH adjustment, hydrolysis temperature, etc. Moreover, although the amount to be fixed to the wood can be adjusted by these conditions, the greater the amount, the greater the improvement to the functions of the modified wood, such as flame retardance, microbe resistance, and dimensional stability. Attachment of the metal compound to the wood can be achieved by the method of coating the metal colloid solution onto the wood or immersing the wood in the solution. To bring the fixed amount as close as possible to saturation amount, the coating method has its limitations, so the immersion in the metal colloid solution is preferable.

[0022] Fixing of the colloidal metal oxide to the wood surface is completed relatively quickly. There are no particular restrictions on the fixation amount, but when the metallic compound has fixed to the whole of the wood surface, no more fixation will occur. If the metallic compound is fixed to the whole surface, then the fixation effect is saturated. Because

the colloidal metal compound is prone to flocculation and sedimentation, it should be used for fixation to wood as soon as possible after manufacture. Fixing of metal compound to wood is performed by bringing the colloidal metal solution into contact with the wood surface. In practice, although the colloid solution may be coated onto the wood, the more effective method is to immerse the wood in a liquid in which the colloidal metallic compound is present. During immersion, energy is imparted to aid uniform fixation of the colloidal metallic compound to the wood.

[0023] To increase the amount of metallic compound fixed to the wood, it is necessary to efficiently replace the wood's air bubbles, moisture, and so forth with the colloidal metallic compound. To achieve this, it is desirable to impart energy during fixation. Suitable means for imparting energy include heating to supply physical energy by convective heat transfer etc., thermal radiation methods such as infrared rays to supply radiant energy, energy wave methods using short wavelength energy waves to induce electric or magnetic fields, (electromagnetic waves such as very high-frequency waves, ultra high-frequency waves, microwaves, milliwaves, etc.), and methods for exciting ions in the wood or metal compound solution, such as use of ultraviolet rays and electron beams. It is also favorable to raise the temperature of the wood in advance to

that of the colloid solution, to coat or immerse the wood in advance with a surfactant or the like in order to facilitate penetration of the colloidal metallic compound into the wood, or to add the surfactant to the colloid solution in advance. These methods are effective in cases where it is necessary to increase the thickness of metallic compound fixed to the surface.

[0024] The optimum conditions for production of the colloidal metal solution differ according to type of solvent, type of metal in the metal salts, type of counter-ion, dissolved concentration, hydrolysis temperature, stirring, pH adjustment, and so forth. For example, if  $\text{FeCl}_3$  is used in a concentration of 10 g/l, a colloidal iron compound is obtained by stirring thoroughly at 50°C to 80°C and slowing adjusting pH so that it is less than 2.5. Flocculation and sedimentation occur if the temperature is below 50°C, pH is greater than 2.5, and stirring is insufficient. On the other hand, when using  $\text{Fe}_2(\text{SO}_4)_3$  as the metal salt, the iron compound will undergo flocculation and sedimentation, and a colloid solution cannot be obtained whatever concentration,

/5

temperature, pH, and stirring conditions are selected. Moreover, if using  $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$  at a concentration of 10g/l, at a pH of less than 5.6 a colloidal aluminum oxide is obtained, whereas at a pH

of greater than 6, flocculation and sedimentation occur, and a colloid solution is not obtained.

[0025] When  $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$  is used at a concentration of 10g/l, at a pH of less than 4.5 a colloidal copper compound is obtained, whereas at a pH of greater than 5, although there is precipitation of particles, flocculation and sedimentation occur, and a colloid solution is not obtained. Particles of a metal colloid of copper are smaller if ammonia is used as the base rather than sodium oxide or potassium hydroxide.

[0026] Cleaning is performed after the metal compound is fixed to the wood. There are no particular restrictions on the cleaning method as long as it is aqueous cleaning capable of thoroughly removing any adhered material such as the original metal salt, alkali, acid, solvents other than water, non-fixed metal compound, by-product salts, etc. The water used is generally mains water, well water, ion exchange water, or industrial water. There are no restrictions on the temperature of the water used. For economic reasons, normal temperature is used. When hot water of 50°C to 70°C is used, cleaning is more efficient. Moreover, aqueous cleaning may be carried out after removing adhesions using a suitable acid, alkali, solvent, or detergent that will not dissolve the fixed metallic compound or strip the same from the wood. This may make aqueous cleaning more effective. In such cases, the acid or alkali may be a

mineral acid such as hydrochloric acid, sulfuric acid, or nitric acid, or an organic acid such as acetic acid or formic acid. For the base, it is practical to use easily industrially obtainable alkalis such as sodium hydroxide, potassium hydroxide or ammonia. For the detergent, examples are non-ionic, anionic or cationic surfactants or the like dissolved in water, acid or alkali. The solvent can, for example, be the solvent used when fixing the metallic compound.

[0027] There are no restrictions on the aqueous cleaning method, but soak cleaning is efficient. Soak cleaning is the method of chemically cleaning the wood by soaking in water. Cleaning efficiency is increased by sloshing the wood in a vessel or agitating the water with air or the like. Cleaning speed can be increased by combining physical cleaning such as barrel (rotation) cleaning or ultrasonic cleaning. Ultrasonic cleaning is the method of cleaning out the wood by the cavitation effect of ultrasonic vibration. Barrel (rotation) cleaning is the method of cleaning out the wood by placing it in a rotating vessel. Cleaning efficiency can be improved by deliquoring, either before cleaning or while repeating cleaning and dehydration. The simplest methods of deliquoring and dehydration are to leave the wood until the reaction liquid or washing liquid stop dripping. During this stage, shaking is effective. The washing liquid is dried off by a suitable method.

[0028] For the wood to which this invention is applied, there are no particular restrictions on the type of tree, and they may be coniferous or broadleaf trees. Suitable tree species include Japanese red pine [*Pinus densiflora*], ginkgo, udo [*Aralia cordata*], ezo spruce [*Picea jezoensis*], oak, Japanese Judas tree [*Cercidiphyllum japonicum*], Japanese Larch (*Larix kaempferi*), paulownia, camphor tree, black pine [*Pinus thunbergii*], chestnut, zelkova, white oak [*Quercus serrata*], castanopsis, linden, Japanese white birch [*Betula platyphylla* var. *japonica*], Japan cedar [*Cryptomeria japonica*], Sakhalin fir [*Abies sachalinensis*], Kalopanax, Japanese elm [*ulmus davidiana* var. *japonica*], hickory, cypress, beech, haw, mahogany, Mongolian oak [*quercus mongolica* var. *grosseserrata*], peach, and lauan. The wood to which the colloidal metallic compound of this invention is fixed may be in various forms such as logs, square lumber, board, plywood, wood chips, etc.

[0029] The wood to which the colloidal metallic compound of this invention is fixed is preferably used for the pillars and other framework members in timber buildings, wall parts such as wood tiles and wood bricks, ceiling parts such as ceiling board, floor parts such as flooring material, and as an interior material used in general housing, multi-dwelling housing, public housing, other residential spaces, etc. It may also be used as

composite materials such as particle board, wood-cement board, etc.

[0030]

[EMBODIMENTS] Specific examples are described below by means of embodiments.

[Measuring method]

(Specific gravity): In conformity with JIS Z 2101.

Specific gravity was calculated from weight and volume.

(Water content): In conformity with JIS Z 2101.

A sample was weighed. The sample was dried at 100°C to 105°C in a drier with good ventilation, and measurement was taken of absolute dry mass when a stable mass was reached.

Water content (%) = (mass before drying - absolute dry mass) / (absolute dry mass) x 100.

(Water absorption): A sample was weighed. The sample was immersed in fresh water at 25°C for 24 hours.

Water absorption rate (%) = (mass directly after 24 hour immersion - absolute dry mass) / (absolute dry mass) x 100

[0031] (Dimensional stability): The length of the sample was measured over the radial direction and the fiber direction. The sample was dried at 100°C to 105°C in a drier with good ventilation, and length over the radial direction and the fiber direction were measured when stable mass was reached. The sample

was immersed in fresh water at 25°C for 24 hours, and length over the radial direction and the fiber direction were measured.

Shrinkage (%) after drying = (length before drying - length after drying) / length after drying x 100.

Expansion (%) after immersion = (length after immersion - length before immersion) / length before immersion x 100.

Values were obtained for the radial direction and the fiber direction.

(Combustibility): A sample was placed in a crucible and left in an electric furnace at 600°C for 3 hours. Changes in form and condition at the time of combustion were observed visually.

(Mold resistance): After being left in a room for 1 week and allowing bacterial contamination, a sample was kept in a constant temperature and moisture chamber at 90 % humidity, 35°C for 1 month, at which point the development of fungus was visually inspected.

[0032] (Embodiment 1) In a reaction vessel, 1000 ml of a 10 g/l aqueous solution of FeCl<sub>3</sub> was prepared and heated to 70°C. The pH was adjusted to 1.8 with caustic soda while thoroughly stirring.

/6

Rectangular wood chips of Japanese cypress [Chamaecyparis obtusa] 30 mm x 30 mm x 10 mm were immersed for 10 minutes. Subsequently, the wood was thoroughly washed in mains water and then dried at 80°C for 8 hours to obtain a modified wood.

[0033] (Embodiment 2) In a reaction vessel, 1000 ml of a 10 g/l aqueous solution of CuCl<sub>2</sub> was prepared and heated to 70°C. The pH was adjusted to 3.5 by dripping ammonia while thoroughly stirring. Rectangular wood chips of Japanese cypress [Chamaecyparis obtusa] 30 mm x 30 mm x 10 mm were immersed for 10 minutes. Subsequently, the wood was thoroughly washed in mains water and then dried at 80°C for 8 hours to obtain a modified wood.

[0034] (Comparison example 1) Rectangular wood chips of Japanese cypress [Chamaecyparis obtusa] 30 mm x 30 mm x 10 mm as used in embodiment 1 were dried at 80°C for 8 hours.

[0035] The modified wood and wood chips thus obtained were left in a temperature-controlled room at 20°C and a humidity of 60 %, and, after constant mass was reached, were evaluated under the aforementioned measurement parameters. The results are shown in Table 1. The untreated wood chips underwent ashing in the combustibility test and showed mold growth in the mold-resistance test, whereas the wood chip treated with the iron compound showed improved flame retardance and a slight improvement in dimensional stability. Furthermore, the wood chip treated with the copper compound manifested mold resistance as well as improved flame retardance and a slight improvement in dimensional stability.

[0036]

[Table 1]

| 試験体         | 実験例1                             | 実験例2           | 比較例1    |
|-------------|----------------------------------|----------------|---------|
| 比重          | 0.34                             | 0.34           | 0.33    |
| 含水率(%)      | 10.6                             | 10.3           | 11.6    |
| 吸水率(%)      | 16.2                             | 17.8           | 30.0    |
| 寸法安定性       |                                  |                |         |
| 収縮率(%) 半径方向 | 0.13                             | 0.13           | 0.15    |
| 収縮率(%) 織維方向 | 2.5                              | 3.1            | 3.4     |
| 膨張率(%) 半径方向 | 0.08                             | 0.06           | 0.10    |
| 膨張率(%) 織維方向 | 2.2                              | 1.9            | 2.9     |
| 燃焼性         | 炭化してわずかに灰化したもの<br>灰化元の形状をとどめていた。 |                | 灰化      |
| 腐さび性        | カビが発生した                          | カビの発生は認められなかった | カビが発生した |

Table 1 [See above for numbers]

| Specimen                          | Embodiment 1                                                                    | Embodiment 2           | Comparison example 1 |
|-----------------------------------|---------------------------------------------------------------------------------|------------------------|----------------------|
| Specific gravity                  |                                                                                 |                        |                      |
| Water content (%)                 |                                                                                 |                        |                      |
| Water absorption (%)              |                                                                                 |                        |                      |
| Dimensional stability             |                                                                                 |                        |                      |
| Shrinkage (%)<br>radial direction |                                                                                 |                        |                      |
| Shrinkage (%)<br>fiber direction  |                                                                                 |                        |                      |
| Expansion (%)<br>radial direction |                                                                                 |                        |                      |
| Expansion (%)<br>fiber direction  |                                                                                 |                        |                      |
| Combustibility                    | Although carbonized and slight shrinkage, substantially retained original shape |                        | Ashed                |
| Mold-resistance                   | Mold grew                                                                       | No mold growth evident | Mold grew            |

[0037] (Embodiment 3) In a reaction vessel, 1000 ml of a 10 g/l aqueous solution of FeCl<sub>3</sub> was prepared and heated to 70°C. The pH was adjusted to 1.8 with caustic soda while thoroughly stirring.

White meranti wood chips were immersed for 10 minutes, and then thoroughly washed in mains water to obtain a modified wood.

[0038] (Embodiment 4) In a reaction vessel, 1000 ml of a 10 g/l aqueous solution of AlCl<sub>3</sub>·6H<sub>2</sub>O was prepared and heated to 70°C. The pH was adjusted to 3.5 with caustic soda while thoroughly stirring. White meranti wood chips were immersed for 10 minutes, and then thoroughly washed in mains water to obtain a modified wood.

[0039] (Comparison example 2) White meranti wood chips were washed in mains water and thoroughly dried.

[0040] For each of the wood chips obtained above, a mixture of said wood chip and cement was prepared and mixed with water according to the formula described below, then molded and cured using standard methods to obtain a wood-cement board. After curing for 4 weeks by standard methods, bending strength was evaluated. The results of evaluation are shown in Table 2.

[Formula]

Wood chips: 20 parts weight; portland cement: 33 parts weight; water: 42 parts weight.

Bending strength was evaluated in conformity with JIS A 1408.

[0041]

[Table 2]

/7

| Wood piece                                            | Embodiment 3 | Embodiment 4 | Comparison example 2 |
|-------------------------------------------------------|--------------|--------------|----------------------|
| Bending strength <sup>*1</sup> (kgf/cm <sup>2</sup> ) | 80           | 85           | 50                   |

\*1: Bending strength = numerical value of bending failure

strength divided by corresponding cross-sectional area.

[0042] Sufficient bending strength was not obtained in the untreated wood chips, but was obtained when using wood chips of modified woods treated with metallic compounds. By fixing a metallic compound to wood, it is thought that the wood extractives that hinder cement curing are prevented from leaching from the wood surface into the cement.

[0043]

[EFFECTS OF THE INVENTION] The wood of this invention can be modified by an extremely simple method and can confer functions such as flame retardance, microbe resistance, and dimensional stability. Because the metallic compound is only fixed to the surface, it is possible to produce a wood that overcomes most of the defects without compromising the qualities of the wood itself, such as being light weight, heat insulation, and moisture absorption. Therefore, it can be used for pillars,

floors, roof spaces, and other aspects of wooden construction, and for interiors, furniture, etc. Moreover, when used as a composite material with cement, the modified wood of this invention has the effect of controlling the leaching of components that hinder cement curing, and is therefore suitable for use in a wood-cement board.